

THE STUDY AND INTERPRETATION OF STHE WITH COMPUTATIONAL FLUID DYNAMICS AS TOOL

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ABSTRACT

In this work study has been made on the computational fluid dynamics analysis of the shell and tube heat exchanger (STHE). CFD was used for the design and analysis of this heat exchanger. In the analysis water and nano fluid are taken for study. Discussion has been made on the various boundary conditions used. The resulting navier stokes equations are solved with the help of a software named as "ANSYS". Temperature, velocity and pressure distribution are analyzed. A comparative study is made for water and nano fluid. The temperature distribution and velocity distribution are studied and analyzed for water as well as nano fluid. It is found from the results that nano fluid is more effective as compared to water

KEYWORDS: STHE, CFD, Temperature Distribution, ANSYS, Velocity Distribution & Heat

Received: May 03, 2019; **Accepted:** May 24, 2019; **Published:** Jun 24, 2019; **Paper Id.:** IJMPERDAUG201931

INTRODUCTION

The important objective of a heat exchanger is the transport of heat. Almost all the processes demands a necessity of heating or cooling of fluids to obtain required thermal conditions. There is a requirement of two fluids, one that require change in energy and a second one that can provide this change. The two fluids flow inside and outside the pipe. In this arrangement the mixing of two fluids does not take place. Due to this reason this type of arrangement is useful where purity of the product is to be ensured. Another advantage of this type of arrangement is a quick transfer of large amount of heat. Kim et al. [2001] studied the hydraulic and thermal performance of multi layered fin and flat tube heat exchanger with different inclination angles. For a heat exchanger tests were conducted under different surface conditions for Reynolds number ranging between 100 – 300 at an angle of 27 degree with fin pitch and flow depth values. The inclination angle ($-60 < \theta < 60$ degree) or the upstream duct presence or absence do not affect significantly the heat transfer performance in dry and wet surface conditions. But the pressure drop got increased with the inclination angle. The heat transfer coefficients and pressure drops for the wet conditions revealed the importance of the role of condensate drainage. Kakac, S. et al. [2002] studied the function and objectives of heat exchangers. Applications of heat exchanger had been studied. Classification of heat exchanger was also studied. The application of heat exchanger is also in a car radiator using an antifreeze engine cooling fluid. It was told that fishes and whales circulation system also uses heat exchanger. In this case it was studied that one of the side is having cold blood and the other is having hot blood. Also the important thing studied was that this helps in preventing heat loss while swimming in cold water. The importance of heat exchanger was also found in the tongues of some whales. Depending upon the various conditions like chemical composition, phase, fluid used and temperature large scale industries also found importance of heat exchanger. Kumar, Ravi et al. [2002] reported the transfer of heat during film condensation of R-134a and steam over a single finned tube. The study

was made for plain tube, Circular Integral Fin Tubes (CIFT), Spine Integral Fin Tubes and Partially Spined Integral Fin Tubes (PCIFT). The PCIFT tube augmented the heat transfer coefficient by 20% for the condensation of steam and R134a by 11% in comparison with the CIFT. Belghazi et al. [2003] determined the local coefficient of heat transfer for the condensation process in case of HFC 134 and different non azeotropic compositions. Commercially available finned tubes were utilized in experiments. Apart from experimentally measured data, HTC was also calculated analytically by modified Wilson plot method and theoretically by Bell and Ghaly method (also called as equilibrium method or condensation curve method). The Bell and Ghaly method was found to be underestimating the HTC. Further, a modified condensation curve was used which showed improvement but with slight overestimation. It was found that the HTC decreased more in case of non-azeotropic mixture as compared to pure fluid. It was also found that while using non-azeotropic mixture HFC 23 – HFC 134a, the HTC increased in the first row due to the disturbance in diffusion layer by the condensate flowing from the upper rows. Naphon, P. et al. [2006] varied the rate of mass flow and studied transfer of heat and drop in pressure characteristics in horizontal double pipes with helical ribs of different height to diameter and pitch to diameter ratios. Cold water at temperatures between 15 ° to 20 ° C and hot water at temperatures between 40 ° to 50 ° C were used as working fluids for shell and tube sides respectively. It was found that helical ribs significantly increased the HTC and pressure drop. Non-isothermal correlations between HTC and pipe friction factor of ribbed and plain pipe in terms of Reynolds and Prandtl number were also proposed based on the experimental observations. Osman et al. [2012] investigated the augmentation of rate of transfer of heat during the condensation of the steam using integral fin tubes of different materials with fin densities 15, 13 and 11 fins per inch (FPI). When they compared the heat transfer performance of enhanced tubes with smooth plain tubes, the tube of eleven FPI exhibited the greatest heat transfer enhancement consistently. Xie et al. [2014] exhibited the transfer of heat in condensation on a tube which is horizontal and having 14.8 mm inner diameter and 1200 millimeter length with a mesh cylinder which is hollow by packaging two layers of mesh screen surface. Mesh pore surface has a significant impact on the stratified flows. It was found that thermal resistance was greatly decreased and the rate of heat transfer was augmented. Cui and Tafti [2002] studied the multi-louvered fin in three dimensions with flow and heat transport. The geometry includes the angled part of the louver and its transition to the flat landing along the fin height. Perrotin and Clodic [2004] determined the transfer of heat and drop of characteristics using the 2- D and 3- D models of compact heat exchangers. Simulation was performed and comparison was made with experimental values. Using this flow configuration, thermal wake effects and flow non steadiness were studied.

OBJECTIVES

- Design and analysis of STHE using computational fluid dynamics.
- To develop a CFD simulation in STHE using water and Nano fluid.

GEOMETRY

Table 1: Geometric Dimensions of Heat Exchanger

Length of STHE, L	400 millimeter
Inner diameter, D_i	15 millimeter
Outer diameter, D_o	34 millimeter
Number of tubes	7
Baffles in Numbers	5
Central spacing between baffles	74.5 millimeter
Angle of inclination	0 degree

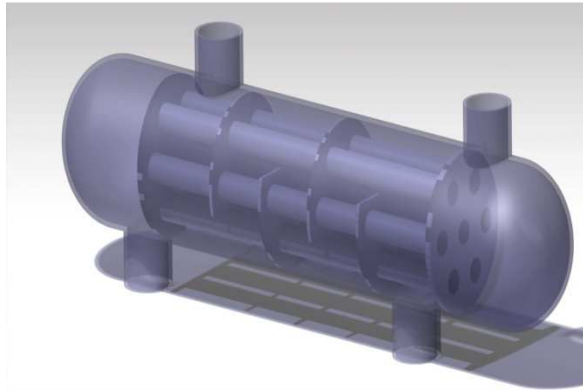


Figure 1: Design of STHE

METHODOLOGY

ANSYS is used for the simulation of STHE. Geometry is drawn in solid works and simulation is performed in fluent.

- Geometry related to the problem is identified
- Meshing is done which may be uniform or non uniform
- Outline the boundary conditions
- Start the simulation work.
- Analysis of the problem.

Script File

Create/Edit Materials	
Name: water-liquid	Material Type: fluid
Chemical Formula: h2o<l>	Fluent Fluid Materials: water-liquid (h2o<l>)
Mixture: none	
Order Materials by: <input checked="" type="radio"/> Name <input type="radio"/> Chemical Formula	
Fluent Database... User-Defined Database...	
Properties	
Density (kg/m3)	constant 998.2
Cp (Specific Heat) (J/kg-K)	constant 4182
Thermal Conductivity (W/m-K)	constant 0.6
Viscosity (kg/m-s)	constant 0.001003
Change/Create Delete Close Help	

Figure 2: Input Properties for Water (H₂O)

RESULTS AND DISCUSSIONS

Variation of Temperature

The variation of temperature in case of water as a cold fluid is shown in the figure below.

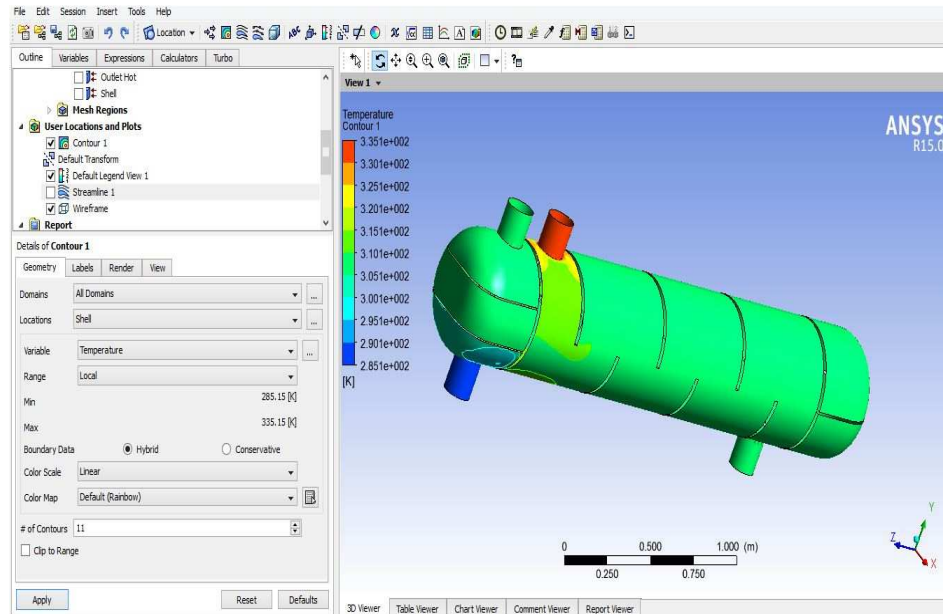


Figure 3: Temperature Distribution across Heat Exchanger (Water)

The temperature contours plots along the length of heat exchangers are given in the figure above. The maximum temperature is 335K and minimum temperature is 285K. The temperature of hot water at inlet was 335 K and at outlet it was 305 K. In case of cold water, the inlet temperature was 315 K and at the outlet it becomes 320 K.

Variation of Velocity

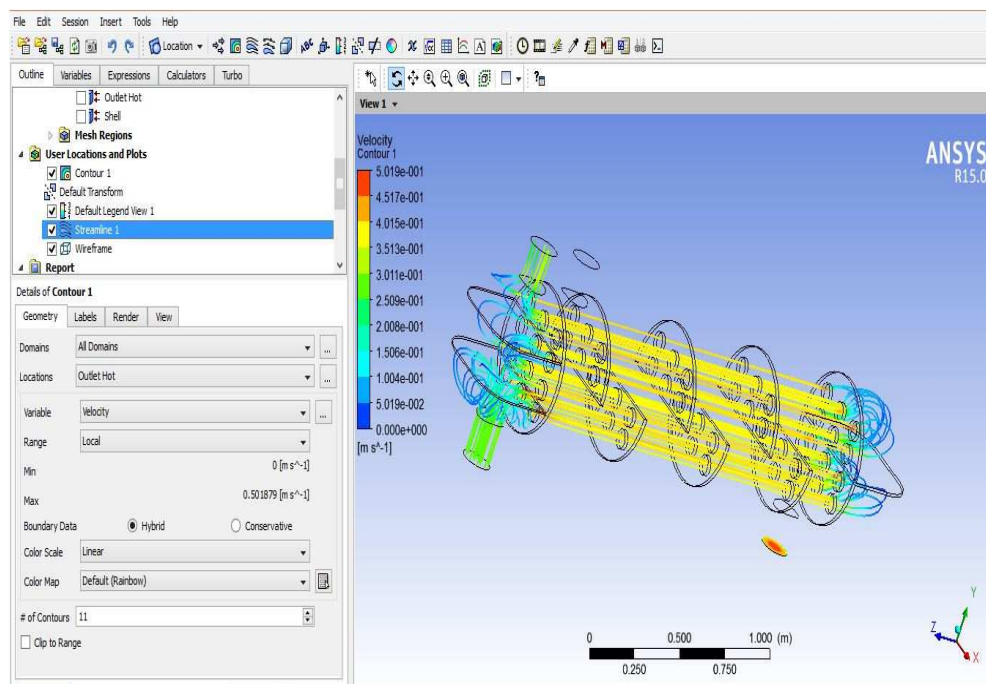


Figure 4: Velocity Distribution Across Heat Exchanger (Water)

The velocity contours plots along the length of heat exchangers is given in the figure above. The maximum velocity is 5.01m/s and minimum velocity is .01m/s.

Variation of Temperature

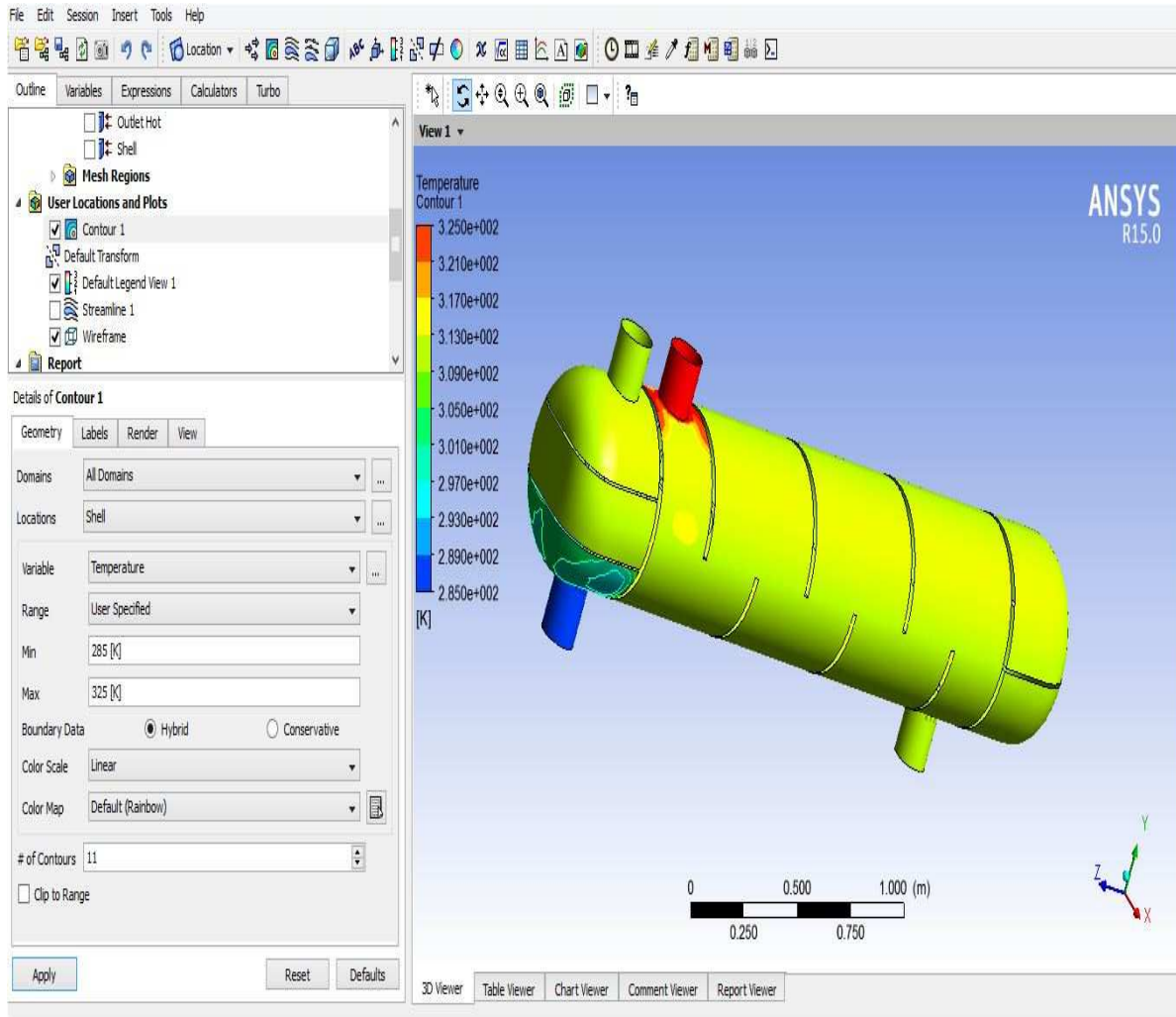


Figure 5: Temperature Distribution across Heat Exchanger (Nano Fluid)

The temperature contours plots along the length of heat exchangers is given in the figure above. The maximum temperature is 325k and minimum temperature is 285k. The temperature of hot water at inlet was 325k and at outlet it was 300k. In case of cold water, the inlet temperature was 290 and at outlet it becomes 297k.

Variation of Velocity

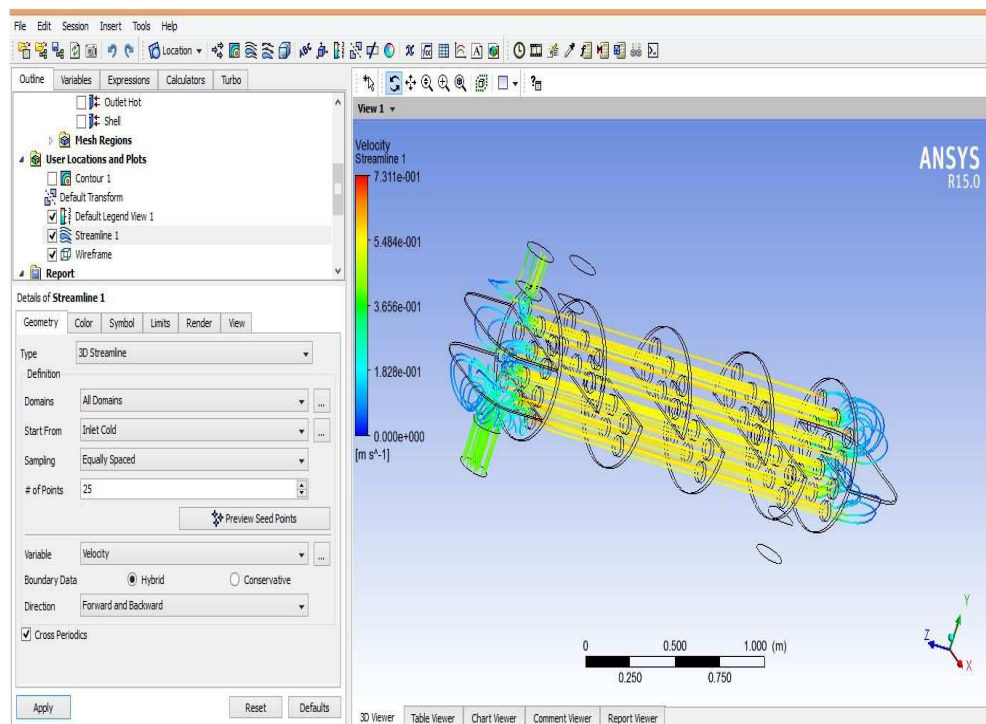


Figure 6: Velocity Distribution Nano Fluid

The velocity contours plots along the length of heat exchangers is given in the figure above. The maximum velocity is 7.31m/s and minimum velocity is .01m/s.

CONCLUSIONS

The temperature and velocity distribution is analyzed using ANSYS and the generated model is compared with water and nano fluid as the coolant materials in heat exchanger. It was found that the nano fluid is more effective as compared with water. Also it is possible that by using helical baffle and different mass flow rate efficiency of model can be improved.

ACKNOWLEDGMENT

I thank our colleagues from Amity University who provided insight and expertise that greatly assisted the research, although they may not agree with all of the interpretations/conclusions of this paper.

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